Climate Change and Goods Movement

Office: California Department of Transportation
Division of Transportation Planning
Office of System and Freight Planning

Contact: Bruce Kemp, bruce_kemp@dot.ca.gov; 916-651-6006

The transportation sector accounts for about 27 percent of all greenhouse gas (GHG) emissions in the United States and about 37 percent of all GHG in California – a measurable contribution to climate change. In turn, climate change will increasingly affect transportation, including freight systems. Highways, rail lines, ports, and airports are becoming increasingly vulnerable to climate change effects, including sea-level rise, coastal erosion, intense weather events, shifting precipitation patterns, and temperature extremes.

Climate Change

Climate change: *Any significant, long-term change in the average climate conditions in a place or region, whether due to natural causes or as a result of human activity*.

Cycles occur naturally, but the rates of change around the globe are increasing, particularly over the past 50 years or so. This is not solely attributable to natural variation; human activities contribute to climate change.

Greenhouse Gases

Greenhouse gases: *Gases that trap heat in the atmosphere.*

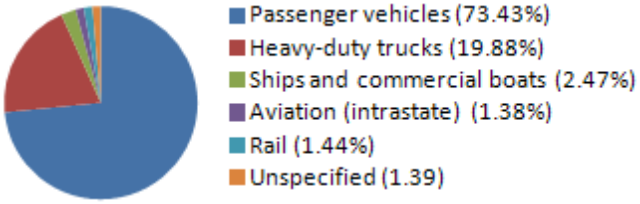
The major GHGs associated with human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (hydro-fluorocarbons, perfluorocarbons, and sulfur hexafluoride. Especially important is CO_2. Global-average CO_2 concentrations in May 2011 were about 394.35 parts per million (ppm), up from about 280 ppm in the mid-19th century.

Soot particles (also called black carbon) – emitted in diesel exhaust and other sources – also contribute to climate change.

Transportation-Related GHG Emissions

California produces roughly 1.4 percent of the world's greenhouse gases. Fossil fuel combustion accounted for 98 percent of gross California CO_2 emissions (about 360 million metric tons CO_2, or about 7 percent of the total U.S. emissions).

Percentage contributions in the transportation sector are shown in this chart.



California Climate Change Effects

California is already experiencing effects:

- Sea levels have risen by as much as seven inches along the California coast over the last century.
- Average annual temperatures have increased since 1920; minimum temperatures (typically at night) are increasing almost everywhere across the state.
- Shifts are occurring in the hydrologic cycle, with less winter precipitation falling as snow, and both snowmelt and rainwater running off sooner in the year.
- These effects may interact with other factors, such as aging levee systems, land subsidence, and seismic activity.

Sea-Level Rise and Storm Surge

Accelerating sea-level rise and storm surge pose the greatest threat to California's infrastructure, including vital coastal highways, railways, seaports, airports, and densely developed areas.

- Sea-level rise is projected to be about 8 inches higher by 2050 and about 18 inches (or higher) by 2100, compared with the 1961-1990 average.
- Potentially vulnerable facilities located near sea level include seaports and airports in the Bay Area and Southern California (Los Angeles and Long Beach).
- Approximately 2,500 miles of roads and railroads are projected to be at growing risk from storm-related coastal flooding due to accelerated sea-level rise.

Higher Temperatures and Air Quality

Temperatures are projected to increase steadily over the course of the 21st century. The amount of warming is likely to exceed the 1°F already experienced, perhaps by another 1 to 2°F. By 2100, temperatures will likely reach 4°F above current levels. Greater warming, possibly as much as 10°F, could occur if GHG emissions continue at a high rate.

- Temperature extremes can increase the risk of road and railroad tracks buckling. Paved surfaces may deteriorate more quickly in hotter conditions.
- Higher temperatures will increase the frequency and severity of ozone air pollution episodes, making it difficult to meet air quality standards.
- Over time, higher global temperatures could open a new sea route connecting the Atlantic and Pacific Oceans along the northern coast of Alaska and Canada, which would benefit the northern ports and cause more competition elsewhere.

Precipitation Changes and Extreme Weather Events

More winter precipitation falling as rain instead of snow could result in intense flows. Roads, tunnels, airport runways, and railroad tracks are likely to be more at risk due to changes in precipitation patterns and increased frequency of weather events.

The combination of higher temperatures, drier climate, and higher frequency of intense rainfall events could increase the risk of landslides that could disrupt major roads and rail lines, causing safety issues and higher maintenance costs.

Winter storms, especially if coinciding with snowmelt and high runoff, may cause flooding and damage to roads and rail lines, overloading of storm water facilities, and damage to canals, tunnels, coastal areas, runways, and railways.

MITIGATION AND ADAPTION

Mitigation: *An intervention or other measure taken to avoid or reduce GHG emissions to slow global warming and/or to improve the uptake (sinks) of GHGs.*

Adaptation: *Responses to the impacts of climate change that cannot be avoided. Adjustments in nature or by humans in response to actual or anticipated manifestations of climate change in order to minimize harm or take advantage of beneficial opportunities*.

General Measures

- Generally do not plan or develop any new significant structure in a place where substantial protection will be needed from sea level rise, storm surges, or coastal erosion during the structure's expected life cycle.
- Create more compact communities with better access to mass transit and other amenities, so people have more transportation choices and do not have to drive as much.
- Implement operational improvements, such as Intelligent Transportation Systems.
- Institutionalize energy efficiency, GHG emission reduction measures, and new technology into system planning, project development, operations, and maintenance of transportation facilities, fleets, buildings, and equipment.
- Reduce emissions through mode shift, such as truck to rail. (One intermodal train can carry

as much freight as 280 to 300 trucks, thus reducing congestion and air emissions.)

Trucking and Highways

- Implement programs that provide for fleet replacement, fleet greening, and fuel diversification.
- Encourage retrofits that reduce aerodynamic drag and improve engine efficiency.
- Promote hybridization of trucks and electrification of truck stops.
- Remove bottlenecks, improve access, and take other steps to improve the efficiency of transportation systems to reduce emissions.
- Develop cleaner, more energy-efficient transportation operations.
- Provide dedicated truck lanes, particularly for low- or zero-emission vehicles.
- Lower fuel consumption by reducing congestion and by improving efficiency of transportation systems through smart land use and complete streets.

Rail Lines

- Encourage locomotive replacement, retrofits, or refueling to reduce emissions.
- Support the use of more efficient yard and long-haul locomotives, including the increased use of hybrid technologies.
- Plan for resistant materials. (Climate change is likely to increase demand for reengineered freight facilities that are better able to withstand heat. Heating rails to more than 100 degrees before they are installed improves resistance to later deformation).

Marine Trade and Seaports

- Coastal ports will likely need to adapt in some ways to sea-level rise. Ports may experience increased risks from higher sea levels and storm surges; long-term planning may be appropriate to protect or raise infrastructure, or to replace facilities.
- Rising sea levels could reduce bridge clearances; higher water levels may require adjustments for roll-on/roll-off port facilities at high tides.
- Change in river water levels could reduce transportation, limit cargo, or cause vessel redesign. Changes in silt and debris buildup resulting from runoff or intense storm events may affect channel depth and increase dredging costs.
- Ports will need to consider anticipated future average sea levels when building new infrastructure. In cases where current infrastructure may not be high enough for its useful lifespan, ports may need to consider armoring or increase structure heights.
- Higher sea levels may threaten ports' environmental mitigation projects. Some port lands may contain contaminated or potentially contaminated industrial areas. Higher water levels may require new containment methods to prevent leeching of contaminants.
- Vessel-related measures include electrifying ship support systems in port (a process known as cold-ironing), an ocean-going vessel speed reduction program ("slow-steaming," which reduces the amount of fuel consumption), and other "clean ship" measures such as better design to reduce resistance, harnessing of wind or solar energy, and improvements in engine efficiency.

Air Cargo

- Airport runways in coastal areas face inundation unless effective protective measures are taken. Over the next 50 years, airport facilities may need to be relocated, replaced, armored, restricted, or closed.
- Unless exposed assets are raised and/or protected by seawalls, they may experience increasing flooding as storm surges reach higher and farther inland.